eCook Myanmar Prototyping

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Acknowledgement

The findings presented in this report would not have been possible without the kind and generous support of the staff at REAM, both those named as authors and the supporting staff. They helped reveal what really goes on in kitchens in Myanmar and to design, build and test various devices that closely match these needs and aspirations. Their willingness to experiment and share their experiences created an unexpectedly rich learning opportunity, for which we are very grateful. Finally, we thank the donors, UK Aid (DfID) via Innovate UK for partial funding and the directors and shareholders of Gamos who matched the funding for the benefit and public good of Myanmar. Additional analysis was carried out under the Modern Energy Cooking Services (MECS) programme, also funded by UK Aid.

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Executive Summary

This report summarises the findings **from the prototyping carried out in Myanmar**, with the aim of informing the development of a battery-supported electric cooking concept, eCook. It is part of a broader programme of work, designed to identify and investigate the opportunities and challenges that await in high impact markets such as Myanmar.

A range of methodologies were employed, including kitchen laboratory testing, observational field visits, reverse engineering and prototype assembly. The appliances tested and prototypes assembled were showcased on several occasions:

- ADB (Asian Development Bank) mini-grids workshop – raise awareness amongst key stakeholders that cooking on battery-supported electricity is possible.
- Focus Group Discussions – solicit feedback from future potential end users on the compatibility of battery-supported electricity with their current and aspirational cooking practices.
- eCook Myanmar Stakeholder Workshop – raise awareness amongst key stakeholders that cooking on battery-supported electricity is possible and catalyse discussion on the role this might play in enhancing access to electricity and clean cooking in Myanmar.

The key findings of the prototyping activities are that electric cooking appliances are highly compatible with Myanmar cooking practices, DC cooking appliance are now available and that the pioneers are already using battery-supported cooking devices. The most compatible appliances include rice cookers, insulated red electric frying pans and Electric Pressure Cookers (EPCs). Several Chinese factories are already producing DC cooking appliances, the most common of which is the DC rice cooker. Several solar electric cooking systems have already been assembled by end users and technical experts looking to find a way to enable cooking with electricity in off-grid regions.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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1 Introduction

This report presents one part of the detailed in country research carried out to explore the market for eCook in Myanmar. In particular, this in country work aims to gain much greater insight into culturally distinct cooking practices and explore how compatible they are with battery-supported electric cooking. The report is rich with detail and is intended to provide decision makers, practitioners and researchers with new knowledge and evidence.

This report presents findings from the design, assembly and testing of a concept prototype to inform the future development of eCook within Myanmar. It is one component of a broader study designed to assess the opportunities and challenges that lay ahead for eCook in high impact potential markets, such as Myanmar, funded through Innovate UK's Energy Catalyst Round 4 by DfID UK Aid and Gamos Ltd. (https://elstove.com/innovate-reports/). A much deeper analysis of the data collected during this project was supported by the Modern Energy Cooking Services (MECS) programme, which included the writing of this report.

The overall aims of the Innovate project, plus the series of interrelated projects that precede and follow on from it are summarised in in *Appendix A: Problem statement and background to Innovate eCook project*.

1.1 Background

1.1.1 Context of the potential landscape change by eCook

The use of biomass and solid fuels for cooking is the everyday experience of nearly 3 billion people. This pervasive use of solid fuels and traditional cookstoves results in high levels of household air pollution with serious health impacts; extensive daily drudgery required to collect fuels, light and tend fires; and environmental degradation. Where households seek to use 'clean' fuels, they are often hindered by lack of access to affordable and reliable electricity and/or LPG. The enduring problem of biomass cooking is discussed further in *Appendix A: Problem statement and background to Innovate eCook project*, which not only describes the scale of the problem, but also how changes in renewable energy technology and energy storage open up new possibilities for addressing it.

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1.1.2 Introducing 'eCook'

eCook is a potentially transformative battery-supported electric cooking concept designed to offer access to clean cooking and electricity to poorer households (HHs) currently cooking on charcoal or other polluting fuels (Batchelor 2013; Batchelor 2015a; Batchelor 2015b). Enabling affordable electric cooking sourced from renewable energy technologies, could also provide households with sustainable, reliable, modern energy for a variety of other purposes.

A series of initial feasibility studies were funded by UK Aid (DfID) under the PEAKS mechanism (available from https://elstove.com/dfid-uk-aid-reports/). Slade (2015) investigated the technical viability of the proposition, highlighting the need for further work defining the performance of various battery chemistries under high discharge and elevated temperature. Leach & Oduro (2015) constructed an economic model, breaking down PV-eCook into its component parts and tracking key price trends, concluding that by 2020, monthly repayments on PV-eCook were likely to be comparable with the cost of cooking on charcoal. Brown & Sumanik-Leary's (2015), review of behavioural change challenges highlighted two distinct opportunities, which open up very different markets for eCook:

- PV-eCook uses a PV array, charge controller and battery in a comparable configuration to the popular Solar Home System (SHS) and is best matched with rural, off-grid contexts.
- Grid-eCook uses a mains-fed AC charger and battery to create distributed HH storage for unreliable or unbalanced grids and is expected to best meet the needs of people living in urban slums or peri-urban areas at the fringes of the grid (or on a mini-grid) where blackouts are common.

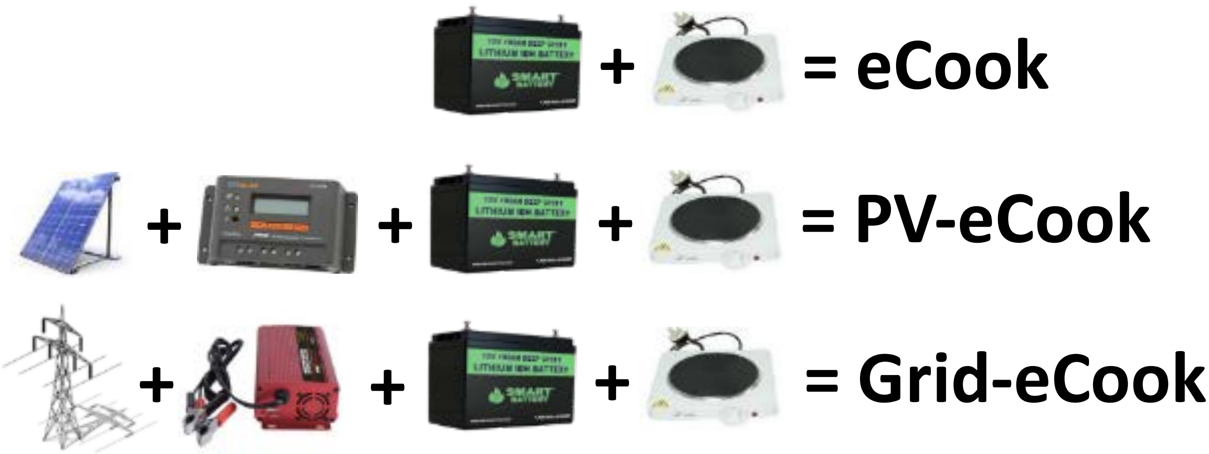

Figure 1: Pictorial definitions of 'eCook' terminology used in this report.

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1.1.3 eCook in Myanmar

Given the technical and socio-economic feasibility of the systems in the near future, Gamos, Loughborough University and the University of Surrey have sought to identify where to focus initial marketing for eCook. Each country has unique market dynamics that must be understood in order to determine which market segments to target are and how best to reach them. Leary et al. (2018) carried out a global market assessment, highlighting that the liberalisation of Myanmar opens the door to a significant charcoal market, with a small percentage of users already cooking on electricity, paving the way for eCook.

The accompanying reports from the other activities carried out in Myanmar can be found at: https://elstove.com/innovate-reports/ and www.MECS.org.uk.

1.2 Aim

The aim of this study is to design, assemble and test an eCook concept prototype in Myanmar.

In particular, the objectives of the study are:

- To design the prototype around the needs and aspirations of Myanmar cooks.
- To use the prototype to demonstrate the concept of cooking on battery-supported electricity to key stakeholders.

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2 Methodology

A range of methodologies were employed:

- Kitchen laboratory testing - understand the compatibility of different electric cooking appliances with Myanmar cuisine
    - Blind taste testing - flavour
    - Controlled cooking tests – energy efficiency
- Observational field visits – see existing solar electric cooking systems assembled by users
- Reverse engineering – understand how existing electric cooking appliances work and
- Prototype assembly - experiment with different configurations of batteries, chargers, inverters and appliances
    - Lead acid – constructed at the beginning of the project, as LiFePO4 not available locally. Initially using inverted and AC appliances, then DC rice cooker.
    - LiFePo4 – ordered direct from Chinese factory. Paired with DC rice cookers.

The full range of appliances assessed and prototypes assembled were showcased on a number of occasions:

- ADB (Asian Development Bank) mini-grids workshop – raise awareness amongst key stakeholders that cooking on battery-supported electricity is possible.
- Focus Group Discussions – solicit feedback from future potential end users on the compatibility of battery-supported electricity with their current and aspirational cooking practices.
- eCook Myanmar Stakeholder Workshop – raise awareness amongst key stakeholders that cooking on battery-supported electricity is possible and catalyse discussion on the role this might play in enhancing access to electricity and clean cooking in Myanmar.

The following sections of this working paper are presented as a photo story. Subsequent versions will add further textual description.

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3 Experimental results

3.1 Controlled cooking tests with blind taste testing

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3.2 Observational field visits

3.2.1 U Than Htay's solar electric cooking system - Dry Zone

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This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

3.2.2 Testing cooking performance with low voltage, Nat Mauk

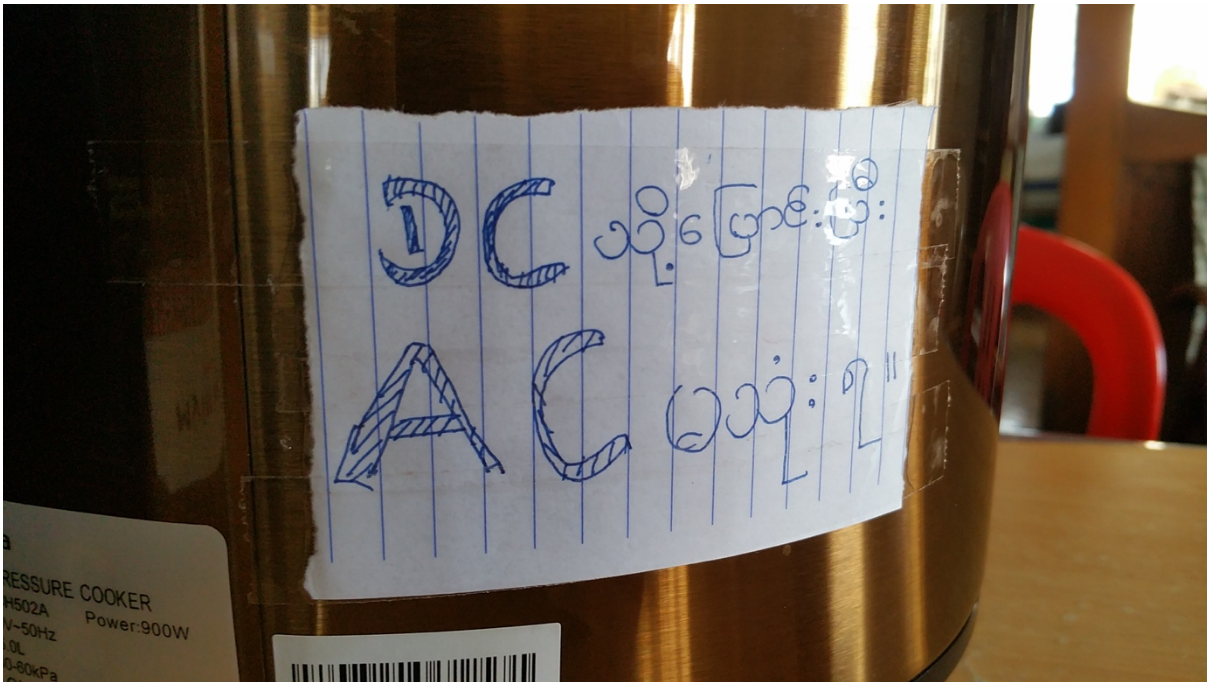
This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

3.2.3 Daw Mo Mo Si's solar electric cooking system, Dry Zone

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

3.3 Reverse engineering

3.3.1 DC cooking appliances



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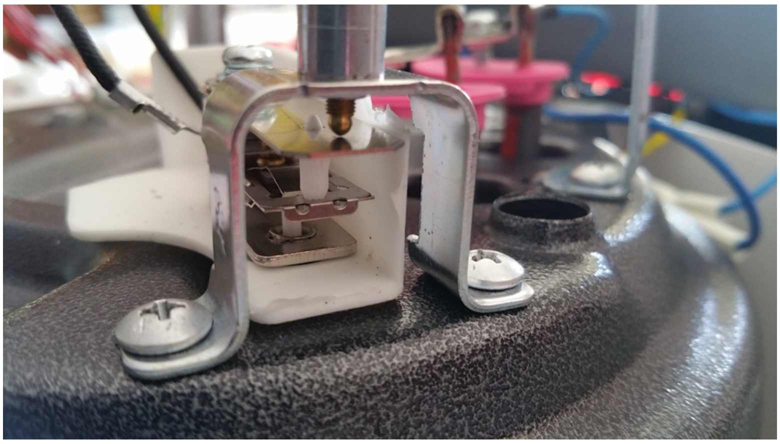
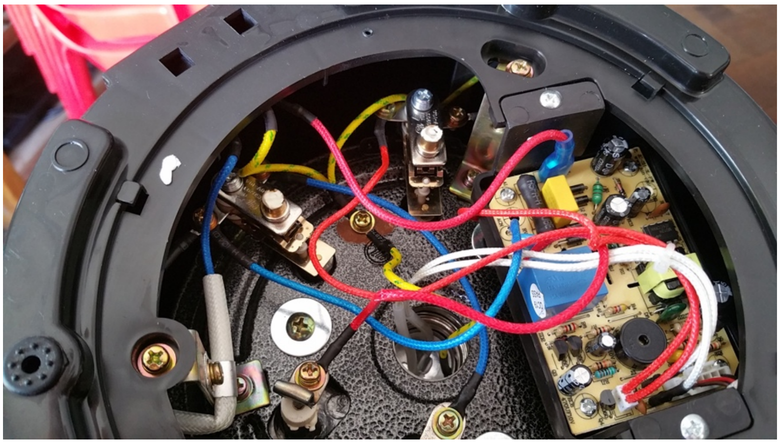
3.3.2 Inside an EPC





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3.4 Prototype assembly

4 Showcasing

4.1 Focus group discussions

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Figure 2: The battery-supported prototype eCook device on display during the participatory cooking session at Hlaine Bone.

Figure 3: The battery-supported cooking system and energy-efficient electric cooking appliances demonstrated during the focus groups.

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4.2 ADB Mini-grids workshop

4.3 eCook Myanmar stakeholder workshop

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4.4 Other events

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5 Conclusion

The key findings of the prototyping activities are that electric cooking appliances are highly compatible with Myanmar cooking practices, DC cooking appliance are now available and that the pioneers are already using battery-supported cooking devices. The most compatible appliances include rice cookers, insulated red electric frying pans and Electric Pressure Cookers (EPCs). Several Chinese factories are already producing DC cooking appliances, the most common of which is the DC rice cooker. Several solar electric cooking systems have already been assembled by end users and technical experts looking to find a way to enable cooking with electricity in off-grid regions.

The findings from this prototyping will be combined with those from the other activities that have been carried under the eCook Myanmar Market Assessment. Together they will build a more complete picture of the opportunities and challenges that await this emerging concept. Further outputs will be available from https://elstove.com/innovate-reports/ and www.MECS.org.uk.

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6 Appendix

6.1 Appendix A: Problem statement and background to Innovate eCook project

6.1.1 Beyond business as usual

The use of biomass and solid fuels for cooking is the everyday experience of nearly 3 Billion people. This pervasive use of solid fuels—including wood, coal, straw, and dung—and traditional cookstoves results in high levels of household air pollution, extensive daily drudgery required to collect fuels, and serious health impacts. It is well known that open fires and primitive stoves are inefficient ways of converting energy into heat for cooking. The average amount of biomass cooking fuel used by a typical family can be as high as two tons per year. Indoor biomass cooking smoke also is associated with a number of diseases, including acute respiratory illnesses, cataracts, heart disease and even cancer. Women and children in particular are exposed to indoor cooking smoke in the form of small particulates up to 20 times higher than the maximum recommended levels of the World Health Organization. It is estimated that smoke from cooking fuels accounts for nearly 4 million premature deaths annually worldwide –more than the deaths from malaria and tuberculosis combined.

While there has been considerable investment in improving the use of energy for cooking, the emphasis so far has been on improving the energy conversion efficiency of biomass. Indeed in a recent overview of the state of the art in Improved Cookstoves (ICS), ESMAP & GACC (2015), World Bank (2014), note that the use of biomass for cooking is likely to continue to dominate through to 2030.

> "Consider, for a moment, the simple act of cooking. Imagine if we could change the way nearly five hundred million families cook their food each day. It could slow climate change, drive gender equality, and reduce poverty. The health benefits would be enormous." ESMAP & GACC (2015)

The main report goes on to say that "The "business-as-usual" scenario for the sector is encouraging but will fall far short of potential." (ibid,) It notes that without major new interventions, over 180 million households globally will gain access to, at least, minimally improved[1] cooking solutions by the end of the decade. However, they state that this business-as-usual scenario will still leave over one-half (57%) of the developing world's population without access to clean cooking in 2020, and 38% without even minimally improved cooking solutions. The report also states that 'cleaner' stoves are

[1] A minimally improved stove does not significantly change the health impacts of kitchen emissions. "For biomass cooking, pending further evidence from the field, significant health benefits are possible only with the highest quality fan gasifier stoves; more moderate health impacts may be realized with natural draft gasifiers and vented intermediate ICS" (ibid)

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barely affecting the health issues, and that only those with forced gasification make a significant improvement to health. Against this backdrop, there is a need for a different approach aimed at accelerating the uptake of truly 'clean' cooking.

Even though improved cooking solutions are expected to reach an increasing proportion of the poor, the absolute numbers of people without access to even 'cleaner' energy, let alone 'clean' energy, will increase due to population growth. The new Sustainable Development Goal 7 calls for the world to "ensure access to affordable, reliable, sustainable and modern energy for all". Modern energy (electricity or LPG) would indeed be 'clean' energy for cooking, with virtually no kitchen emissions (other than those from the pot). However, in the past, modern energy has tended to mean access to electricity (mainly light) and cooking was often left off the agenda for sustainable energy for all.

Even in relation to electricity access, key papers emphasise the need for a step change in investment finance, a change from 'business as usual'. IEG World Bank Group (2015) note that 22 countries in the Africa Region have less than 25 percent access, and of those, 7 have less than 10 percent access. Their tone is pessimistic in line with much of the recent literature on access to modern energy, albeit in contrast to the stated SDG7. They discuss how population growth is likely to outstrip new supplies and they argue that "unless there is a big break from recent trends the population without electricity access in Sub-Saharan Africa is projected to increase by 58 percent, from 591 million in 2010 to 935 million in 2030." They lament that about 40% of Sub-Saharan Africa's population is under 14 years old and conclude that if the current level of investment in access continues, yet another generation of children will be denied the benefits of modern service delivery facilitated by the provision of electricity (IEG World Bank Group 2015).

> "Achieving universal access within 15 years for the low-access countries (those with under 50 percent coverage) requires a quantum leap from their present pace of 1.6 million connections per year to 14.6 million per year until 2030." (ibid)

Once again, the language is a call for a something other than business as usual. The World Bank conceives of this as a step change in investment. It estimates that the investment needed to really address global electricity access targets would be about $37 billion per year, including erasing generation deficits and additional electrical infrastructure to meet demand from economic growth. "By comparison, in recent years, low-access countries received an average of $3.6 billion per year for their electricity sectors from public and private sources" (ibid). The document calls for the Bank Group's energy practice to adopt a new and transformative strategy to help country clients orchestrate a national, sustained, sector-level engagement for universal access.

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In the following paragraphs, we explore how increasing access to electricity could include the use of solar electric cooking systems, meeting the needs of both supplying electricity and clean cooking to a number of households in developing countries with sufficient income.

6.1.2 Building on previous research

Gamos first noted the trends in PV and battery prices in May 2013. We asked ourselves the question, is it now cost effective to cook with solar photovoltaics? The answer in 2013 was 'no', but the trends suggested that by 2020 the answer would be yes. We published a concept note and started to present the idea to industry and government. Considerable interest was shown but uncertainty about the cost model held back significant support. Gamos has since used its own funds to undertake many of the activities, as well as IP protection (a defensive patent application has been made for the battery/cooker combination) with the intention is to make all learning and technology developed in this project open access, and awareness raising amongst the electrification and clean cooking communities (e.g. creation of the infographic shown in Figure 4 to communicate the concept quickly to busy research and policy actors).

Gamos has made a number of strategic alliances, in particular with the University of Surrey (the Centre for Environmental Strategy) and Loughborough University Department of Geography and seat of the Low Carbon Energy for Development Network). In October 2015, DFID commissioned these actors to explore assumptions surrounding solar electric cooking[2] (Batchelor 2015b; Brown & Sumanik-Leary 2015; Leach & Oduro 2015; Slade 2015). The commission arose from discussions between consortium members, DFID, and a number of other entities with an interest in technological options for cleaner cooking e.g. Shell Foundation and the Global Alliance for Clean Cookstoves.

Drawing on evidence from the literature, the papers show that the concept is technically feasible and could increase household access to a clean and reliable modern source of energy. Using a bespoke economic model, the Leach and Oduro paper also confirm that by 2020 a solar based cooking system could be comparable in terms of monthly repayments to the most common alternative fuels, charcoal and LPG. Drawing on published and grey literatures, many variables were considered (e.g. cooking energy needs, technology performance, component costs). There is uncertainty in many of the parameter values, including in the assumptions about future cost reductions for PV and batteries, but the cost ranges for the solar system and for the alternatives overlap considerably. The model

[2] The project has been commissioned through the PEAKS framework agreement held by DAI Europe Ltd.

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includes both a conservative 5% discount rate representing government and donor involvement, and a 25% discount rate representing a private sector led initiative with a viable return. In both cases, the solar system shows cost effectiveness in 2020.

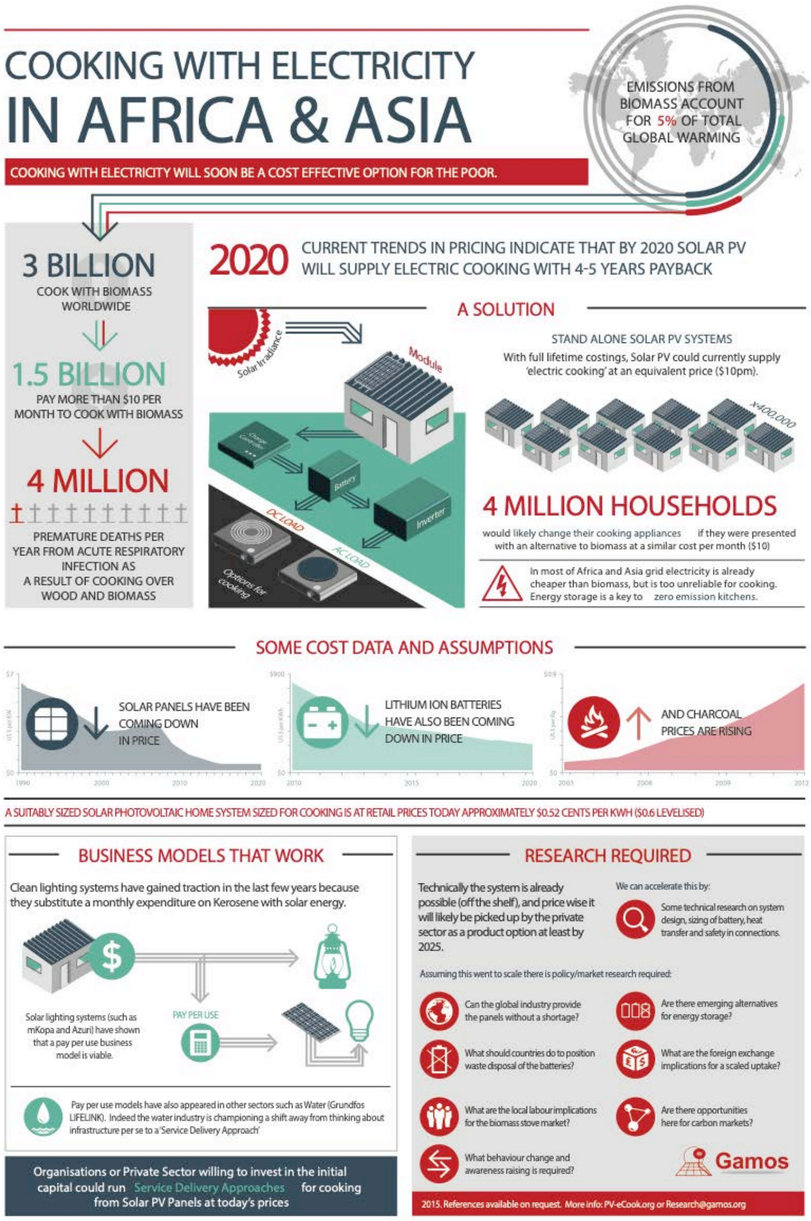

Figure 4 Infographic summarising the concept in order to lobby research and policy actors.

The Brown and Sumanik-Leary paper in the series examines the lessons learned from four transitions – the uptake of electric cooking in South Africa, the roll out of Improved Cookstoves (ICS), the use of LPG and the uptake of Solar Home Systems (SHS). They present many behavioural concerns, none of which preclude the proposition as such, but all of which suggest that any action to create a scaled use of solar electric cooking would need in depth market analysis; products that are modular and paired

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with locally appropriate appliances; the creation of new, or upgrading of existing, service networks; consumer awareness raising; and room for participatory development of the products and associated equipment.

A synthesis paper summarising the above concludes by emphasising that the proposition is not a single product – it is a new genre of action and is potentially transformative. Whether solar energy is utilised within household systems or as part of a mini, micro or nano grid, linking descending solar PV and battery costs with the role of cooking in African households (and the Global South more broadly) creates a significant potential contribution to SDG7. Cooking is a major expenditure of 500 million households. It is a major consumer of time and health. Where households pay for their fuelwood and charcoal (approximately 300 Million) this is a significant cash expense. Solar electric cooking holds the potential to turn this (fuelwood and charcoal) cash into investment in modern energy. This "consumer expenditure" is of an order of magnitude more than current investment in modern energy in Africa and to harness it might fulfil the calls for a step change in investment in electrical infrastructure.

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6.1.3 Summary of related projects

A series of inter-related projects have led to and will follow on from the research presented in this report:

- Gamos Ltd.'s early conceptual work on eCook (Batchelor 2013).
  - The key **CONCEPT NOTE** can be found here.
  - An early infographic and a 2018 infographic can be found here.
- Initial technical, economic and behavioural feasibility studies on eCook commissioned by DfID (UK Aid) through the CEIL-PEAKS Evidence on Demand service and implemented by Gamos Ltd., Loughborough University and University of Surrey.
  - The key **FINAL REPORTS** can be found here.
- Conceptual development, stakeholder engagement & prototyping in Kenya & Bangladesh during the "*Low cost energy-efficient products for the bottom of the pyramid*" project from the USES programme funded by DfID (UK Aid), EPSRC & DECC (now part of BEIS) & implemented by University of Sussex, Gamos Ltd., ACTS (Kenya), ITT & UIU (Bangladesh).
  - The key **PRELIMINARY RESULTS** (Q1 2019) can be found here.
- A series of global & local market assessments in Myanmar, Zambia and Tanzania under the "*eCook - a transformational household solar battery-electric cooker for poverty alleviation*" project funded by DfID (UK Aid) & Gamos Ltd. through Innovate UK's Energy Catalyst Round 4, implemented by Loughborough University, University of Surrey, Gamos Ltd., REAM (Myanmar), CEEEZ (Zambia) & TaTEDO (Tanzania).
  - The key **PRELIMINARY RESULTS** (Q1 2019) can be found here.
- At time of publication (Q1 2019), a new DfID (UK Aid) funded research programme '*Modern Energy Cooking Services*' (MECS) lead by Prof. Ed Brown at Loughborough University is just beginning and will take forward these ideas & collaborations.

This data and material have been funded by UK AID from the UK government; however, the views expressed do not necessarily reflect the UK government's official policies.

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6.1.4 About the Modern Energy Cooking Services (MECS) Programme.

Sparking a cooking revolution: catalysing Africa's transition to clean electric/gas cooking.

www.mecs.org.uk | mecs@lboro.ac.uk

Modern Energy Cooking Services (MECS) is a five-year research and innovation programme funded by UK Aid (DFID). MECS hopes to leverage investment in renewable energies (both grid and off-grid) to address the clean cooking challenge by integrating modern energy cooking services into the planning for access to affordable, reliable and sustainable electricity.

Existing strategies are struggling to solve the problem of unsustainable, unhealthy but enduring cooking practices which place a particular burden on women. After decades of investments in improving biomass cooking, focused largely on increasing the efficiency of biomass use in domestic stoves, the technologies developed are said to have had limited impact on development outcomes. The Modern Energy Cooking Services (MECS) programme aims to break out of this "business-as-usual" cycle by investigating how to rapidly accelerate a transition from biomass to genuinely 'clean' cooking (i.e. with electricity or gas).

Worldwide, nearly three billion people rely on traditional solid fuels (such as wood or coal) and technologies for cooking and heating[3]. This has severe implications for health, gender relations, economic livelihoods, environmental quality and global and local climates. According to the World Health Organization (WHO), household air pollution from cooking with traditional solid fuels causes to 3.8 million premature deaths every year – more than HIV, malaria and tuberculosis combined[4]. Women and children are disproportionately affected by health impacts and bear much of the burden of collecting firewood or other traditional fuels.

Greenhouse gas emissions from non-renewable wood fuels alone total a gigaton of CO_2e per year (1.9-2.3% of global emissions)[5]. The short-lived climate pollutant black carbon, which results from incomplete combustion, is estimated to contribute the equivalent of 25 to 50 percent of carbon

[3] http://www.who.int/indoorair/health_impacts/he_database/en/

[4] https://www.who.int/en/news-room/fact-sheets/detail/household-air-pollution-and-health https://www.who.int/gho/hiv/epidemic_status/deaths_text/en/, https://www.who.int/en/news-room/fact-sheets/detail/malaria, https://www.who.int/en/news-room/fact-sheets/detail/tuberculosis

[5] Nature Climate Change 5, 266–272 (2015) doi:10.1038/nclimate2491

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dioxide warming globally – residential solid fuel burning accounts for up to 25 percent of global black carbon emissions[6]. Up to 34% of woodfuel harvested is unsustainable, contributing to climate change and local forest degradation. In addition, approximately 275 million people live in woodfuel depletion 'hotspots' – concentrated in South Asia and East Africa – where most demand is unsustainable[7].

Africa's cities are growing – another Nigeria will be added to the continent's total urban population by 2025[8] which is set to double in size over the next 25 years, reaching 1 billion people by 2040. Within urban and peri-urban locations, much of Sub Saharan Africa continues to use purchased traditional biomass and kerosene for their cooking. Liquid Petroleum Gas (LPG) has achieved some penetration within urban conurbations, however, the supply chain is often weak resulting in strategies of fuel stacking with traditional fuels. Even where electricity is used for lighting and other amenities, it is rarely used for cooking (with the exception of South Africa). The same is true for parts of Asia and Latin America. Global commitments to rapidly increasing access to reliable and quality modern energy need to much more explicitly include cooking services or else household and localized pollution will continue to significantly erode the well-being of communities.

Where traditional biomass fuels are used, either collected in rural areas or purchased in peri urban and urban conurbations, they are a significant economic burden on households either in the form of time or expenditure. The McKinsey Global Institute outlines that much of women's unpaid work hours are spent on fuel collection and cooking[9]. The report shows that if the global gender gap embodied in such activities were to be closed, as much as $28 trillion, or 26 percent, could be added to the global annual GDP in 2025. Access to modern energy services for cooking could redress some of this imbalance by releasing women's time into the labour market.

To address this global issue and increase access to clean cooking services on a large scale, investment needs are estimated to be at least US$4.4 billion annually[10]. Despite some improvements in recent

[6] http://cleancookstoves.org/impact-areas/environment/

[7] Nature Climate Change 5, 266–272 (2015) doi:10.1038/nclimate2491

[8] https://openknowledge.worldbank.org/handle/10986/25896

[9] McKinsey Global Institute. *The Power of Parity: How Advancing Women's Equality can add $12 Trillion to Global Growth*; McKinsey Global Institute: New York, NY, USA, 2015.

[10] The SE4ALL Global Tracking Report shows that the investment needed for universal access to modern cooking (not including heating) by 2030 is about $4.4 billion annually. In 2012 investment was

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years, this cross-cutting sector continues to struggle to reach scale and remains the least likely SE4All target to be achieved by 2030[11], hindering the achievement of the UN's Sustainable Development Goal (SDG) 7 on access to affordable, reliable, sustainable and modern energy for all.

Against this backdrop, MECS draws on the UK's world-leading universities and innovators with the aim of sparking a revolution in this sector. A key driver is the cost trajectories that show that cooking with (clean, renewable) electricity has the potential to reach a price point of affordability with associated reliability and sustainability within a few years, which will open completely new possibilities and markets. Beyond the technologies, by engaging with the World Bank (ESMAP), MECS will also identify and generate evidence on other drivers for transition including understanding and optimisation of multi-fuel use (fuel stacking); cooking demand and behaviour change; and establishing the evidence base to support policy enabling environments that can underpin a pathway to scale and support well understood markets and enterprises.

The five-year programme combines creating a stronger evidence base for transitions to modern energy cooking services in DFID priority countries with socio-economic technological innovations that will drive the transition forward. It is managed as an integrated whole; however, the programme is contracted via two complementary workstream arrangements as follows:

- An Accountable Grant with Loughborough University (LU) as leader of the UK University Partnership.
- An amendment to the existing Administrative Arrangement underlying DFID's contribution to the ESMAP Trust Fund managed by the World Bank.

The intended outcome of MECS is a market-ready range of innovations (technology and business models) which lead to improved choice of affordable and reliable modern energy cooking services for consumers. Figure 5 shows how the key components of the programme fit together. We will seek to have the MECS principles adopted in the SDG 7.1 global tracking framework and hope that participating countries will incorporate modern energy cooking services in energy policies and planning.

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in cooking was just $0.1 billion. Progress toward Sustainable Energy: Global Tracking Report 2015, World Bank.

[11] The 2017 SE4All Global Tracking Framework Report laments that, "Relative to electricity, only a small handful of countries are showing encouraging progress on access to clean cooking, most notably Indonesia, as well as Peru and Vietnam."

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

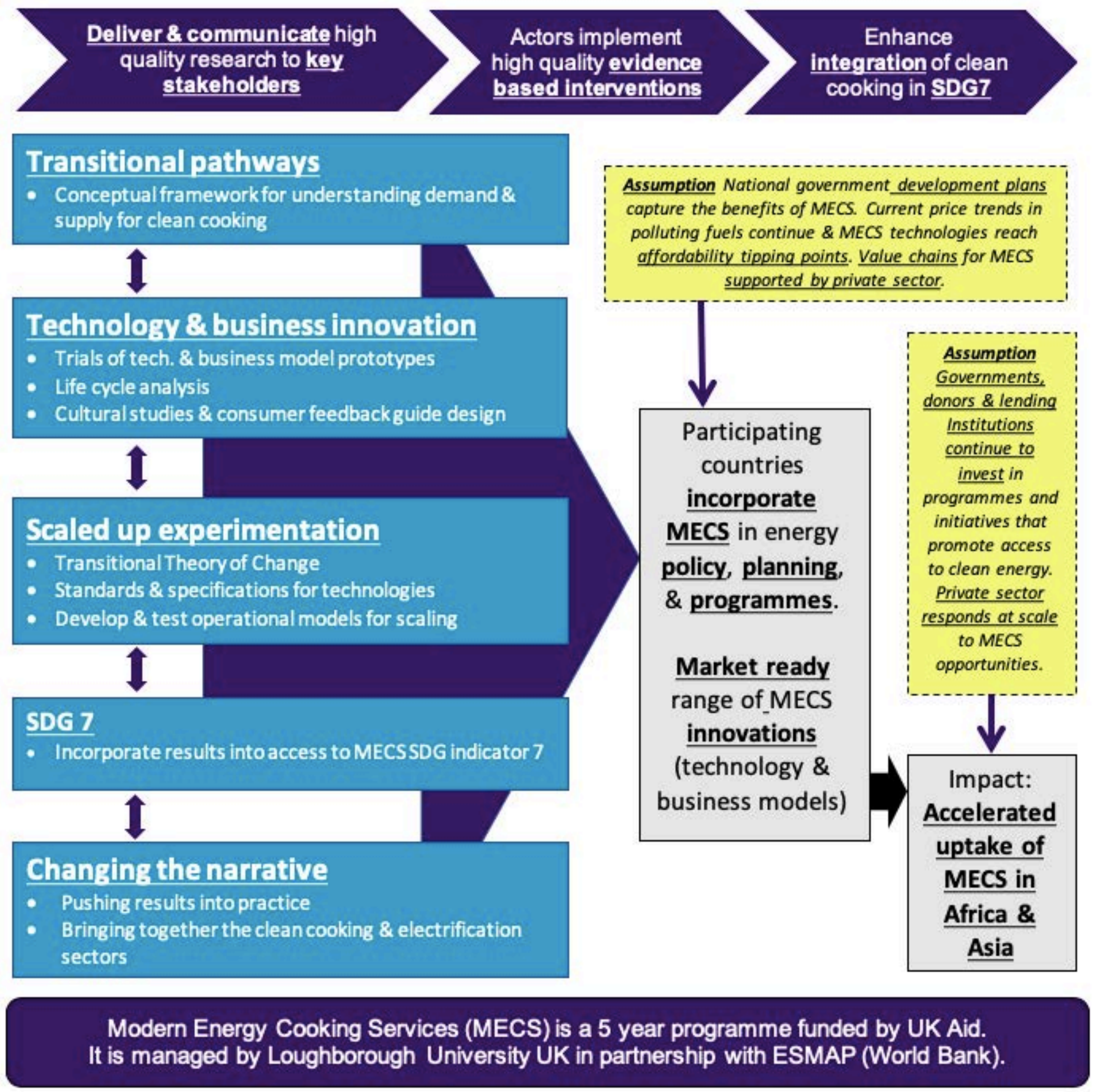

Figure 5: Overview of the MECS programme.

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6.2 Appendix B: List of users & organisations testing = DC LiFePO4 eCook prototypes

Name	Organisation	Location	Role	Purpose	DC Rice Cooker		LiFePO4 batteries		Charger	
					Voltage	Capacity	Quantity	Capacity	Quantity	Max current
	MoI	Yangon	Clean cookstove standards committee	Demonstrations	24V	2l	0		0	
	DRI	Yangon	Solar & clean cooking research	Demonstrations	24V	4l	3	20Ah	3	5A
					12V	4l				
Jon Leary	Gamos	UK	eCook researcher	Demonstrations & prototyping	12V	2l	0		0	
					12V	3l				
					24V	4l				
					24V	5l				
					24V	2l				
Simon Batchelor	Gamos	UK	eCook researcher	Demonstrations & prototyping	24V	3l	0		0	
					12V	4l				
Daw Moe Moe		Sedotra, Magwe	Mini-grid & SHS user	End--user	12V	5l	1	50Ah	1	10A
U Sai Htun Hla	REAM	Shan State	Mini-grid developer	End-user & demonstrations	n/a		1	50Ah	1	10A
U Hla Kyi	REAM	Maw Gyn	Govt grid, mini-grid, generator & SHS user	End-user	12V	2l	1	20Ah	1	5A

	REAM	Yangon	Renewable energy association	End-user	12V 24V	5l 3l	3	20Ah	3	5A
U Kyi Lwin	REAM	Hlaing Bone	Mini-grid user	End-user	12V	3l	1	20Ah	1	5A
U Than Htay	REAM	Nagebone	SHS user	End-user	n/a		4	100Ah	0	

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6.3 Appendix C: :LiFePO4 & DC cooking appliances quotations & invoices

	Comments	Ah	V	Wh	Pieces	Unit price	Price	Shipping	Customs	Total	USD/kWh	DoD	USD/usable kWh
Optimum Nano Energy	**Freight to Yunan, works with lead acid charger**	**100**	**12**	**1200**	**12**	**$ 490.00**	**$ 5,880.00**	**$ 70.00**	**$ 411.60**	**$ 5,950.00**	**$ 413.19**	**0.9**	**$ 459.10**
Wisdom Industrial Power		**100**	**12**	**1200**	**12**	**$ 456.92**	**$ 5,483.04**	**$ 55.00**	$ 383.81	**$ 5,538.04**	**$ 384.59**	**0.9**	**$ 427.32**
Shenzhen FBTech Electronics	**With BMS, inc. freight to Yunnan**	**100**	**12**	**1200**	**1**	**$ 455.00**	**$ 455.00**	**100**	**$ 31.85**	**$ 586.85**	**$ 489.04**	**0.9**	**$ 543.38**
				0			$ -			$ -	#DIV/0!		
Aar Man Thit	Local supplier lead acid cost	100	12	1200	1	121.77122	$ 121.77	0		$ 121.77	$ 101.48	0.5	$ 202.95

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Guangzhou Tesga Power Co.,Ltd

PROFORMA INVOICE

To: Than Htay
PI NO.18031
Email:thanhtay64@gmail.com

From: Coco Gao
Mob/Whatsapp:+86-13726716368
Email:cocogao@tesgapower.com

Model	Spec	UNIT Price (RBM)	Qty(pcs)	Amount (RMB)	Weight (kgs) (±5%)	Total Weight	Size(mm)	Picture
DRC-1202	12V,200W DC Rice Cooker 2L	$18.00	2	$36.00	2.5	5	290*250*150	
DRC-1204	12V,250W DC Rice Cooker 4L	$20.00	2	$40.00	3	6	290*290*295	
DPC-12028	12V,250W DC Pressure Cooker 2.8L	$33.00	2	$66.00	4.5	9	310*265*265	
DPC-1205	12V,250W DC Pressure Cooker 5L	$34.00	2	$68.00	5	10	350*310*310	
IDC2	12V,200W DC Cooker with Pot	$15.50	2	$31.00	2	4	250*250(200	
DWK-1218	12V,150W DC Water Kettle	$14.50	2	$29.00	2.5	5	180*180*175	
DB12	12V,200W DC Blender	$9.50	2	$19.00	1.5	3	365*165*165	
Sub Total				$289.00		42		
The freight cost				RMB200				
Total Payment				$289.00	RMB 2050			

WISDOM INDUSTRIAL POWER CO.,LTD

UNIT 04,7/F, BRIGHT WAY TOWER, 33 MONG KOK RD, KL, HONG KONG

Tel: +86-752-2819469 Fax: +86-752-2818633 email:sales01@bsl-battery.com

BSLBATT

PROFORMA INVOICE

INVOICE NO. PI-17120117CL-TH Date: 7-Dec-17

INVOICE of : 12V 20AH/50AH/100AH wiht charger

Buyer: Than Htay

To: Yi Mon Electronics Co.,Ltd Contact Tel: (95) 1640816

Time of Delivery: After 30 working days production after getting payment Place of delivery: Shenzhen,China

Payment Terms: 100% payment(3170.08USD) by T/T Terms of Price: EXW Shenzhen

Model	Description of Goods	Quantity(pcs)	Unit Price(USD)	Amount (USD)
B-LFP12-20	Dimension(L*W*H)-181*77*170mm Weight--4kg	8	91.38	731.04
B-LFP12-50	Dimension(L*W*H)229*138*213mm Weight--10kg	2	228.46	456.92
B-LFP12-100	Dimension(L*W*H)-323*173*218mm Weight--14kg	4	456.92	1827.68
	5A charger	8	10.15	81.20
	10A charger	2	16.62	33.24
	Freight to Jinan			40.00
			Total Amount:	3170.08

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